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Confirmation of Two Endemic *Athyrium* Species (Woodsiaceae) in Taiwan

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ABSTRACT.—Two endemic species, *Athyrium tripinnatum* Tagawa and *A. minimum* Ching are confirmed to exist in Taiwan. Their taxonomic descriptions, pictures of living plants, illustrations, and additional notes are provided

The most recent checklist of Taiwanese ferns contained 18 species and 2 hybrids in the genus *Athyrium* (Lu and Yang, 2005). Several scientific names recorded in Flora Reipublicae Popularis Sinicae (Wang, 1999) were not recognized by Lu and Yang. However, based on recently collected materials, we believed that at least two of them, *A. tripinnatum* Tagawa and *A. minimum* Ching, should be re-established. In the past, these two species were less-known and usually treated as taxonomic doubtful species in the local flora of Taiwan (Yang and Liu, 2002).

Athyrium tripinnatum was based on the materials from Alishan area, Central Taiwan, and Sziyuanyako area, NE Taiwan. Kuo (1985) synonymised it into *Athyrium foliolosum* T. Moore *ex* R. Sim., which is a misapplied name of *A. fimbriatum* (Hook.) T. Moore in Taiwan (Fraser-Jenkins, 1997; Wang, 1999; Liu and Fraser-Jenkins, 2006). Wang (1999) treated it as a distinct species under the section *Mackinnoniana* (Ching & Y. T. Hsieh) Z. R. Wang, but suggested that the relationship between it and *A. foliolosum* (section *Polystichoides* Ching & Y. T. Hsieh) needed further study. Liu *et al.* (2000) and Lu and Yang (2005) accepted Kuo's classification and regarded it as *A. foliolosum* (= *A. fimbriatum*). After a detailed observation of the morphological characters and spore ornamentation, we confirm *A. tripinnatum* as a valid species and distinct from *A. foliolosum* and *A. fimbriatum* which belong to section *Polystichoides*.

The second species, *Athyrium minimum*, was based on a single collection by Hancock from Tamshui, north Taiwan (Holotype: *Hancock s.n.*, PE!) in 1881. Three small plants were mounted on a specimen sheet with the largest one less

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than 8 cm long (Ching, 1986), and there was a suggestion that these plants might represent precociously fertile specimens of *A. iseanum* Rosenst. (Fraser-Jenkins notes in sched.). Yang and Liu (2002) regarded it as a doubtful species in Taiwan. With the new material, we have confirmed that this taxon is a valid species and Ching's description, which was only based on very few specimens, should be revised.

Following the subdivision scheme of *Athyrium* proposed by Wang (1999), but modified by Fraser-Jenkins (pers. comm.), we placed both *A. minimum* and *A. tripinnatum* into section *Echinoathyrium* Ching & Y.T. Hsieh. The section *Mackinnoniana* included the type of the section *Echinoathyrium* and is therefore a superfluous name of *Echinoathyrium*. The following diagnostic morphological characters belong to this section (Wang, 1997): spore without folded perispore; short spines on adaxial costae and costules; indusia reniform, elliptic, short-linear, J-shaped and hippocrepiform; scales at stipe base usually light brown to brown; we confirmed that *A. tripinnatum* belongs to this section and transferred *A. minimum* into this section as well.

Both species with taxonomic descriptions, illustrations, and notes are presented here.

Athyrium tripinnatum Tagawa Acta Phytotax. Geobot. 6: 163. 1937. **Fig. 1, 3A–C.**

Athyrium foliolosum auct non. T. Moore *ex* R. Sim.: C. M. Kuo, Taiwania 30: 34, 65. 1985; C. M. Kuo, Manu. Taiwan Vasc. Pl. 1: 111, 1997; Yang and Liu. Manu. Taiwan Vasc. Pl. 6: 116; Lu and Yang, Taiwania 50: 150.

Evergreen, terrestrial fern. Rhizome short erect, thick. Stipe 40 (25–70) cm long, bearing numerous lanceolate, russet- or pale-brown scales in its lower half, becoming small and scattered above, absent from the rachis; stipe and rachis purple or rarely green in the living state, glandular on the adaxial side. Fronds membranaceous to herbaceous, lamina 50 (40–70) cm long, 40 (25– 60) cm wide. Lamina broadly lanceolate in small plants, but becoming deltate-lanceolate in larger ones; rachis glandular adaxially, glabrous abaxially; pinnae pinnatifid in small plants, usually pinnate in larger plants; the acroscopic pinnules symmetrical with the basiscopic ones on each pinna; pinnules anadromous, varying considerably in size from small to large, pinnule base ± narrowly attached to the costa, but with a short petiole in lower pinnae of large plants, pinnule-apices narrowly obtuse or somewhat acute. Sori ± large, subreniform, curved, hippocrepiform, or J-shaped, with prominent indusia. Spores somewhat pale-brown, perispore of rugate type, granulate on the surface.

DISTRIBUTION.—Endemic to Taiwan. Altitude 1600–2500 m.

SPECIMENS EXAMINED.—TAIWAN. **Chiayi**: *M. Tagawa 398*. (Isotype. L. photograph from website http://132.229.92.200/Pictures/L0051500/L0051074.jpg); *R. Knapp 544*; **Nantou**: *Y. C. Liu 3626, 5315, 5316, 5318, 5320* (SYSU, TAIF), *P.*

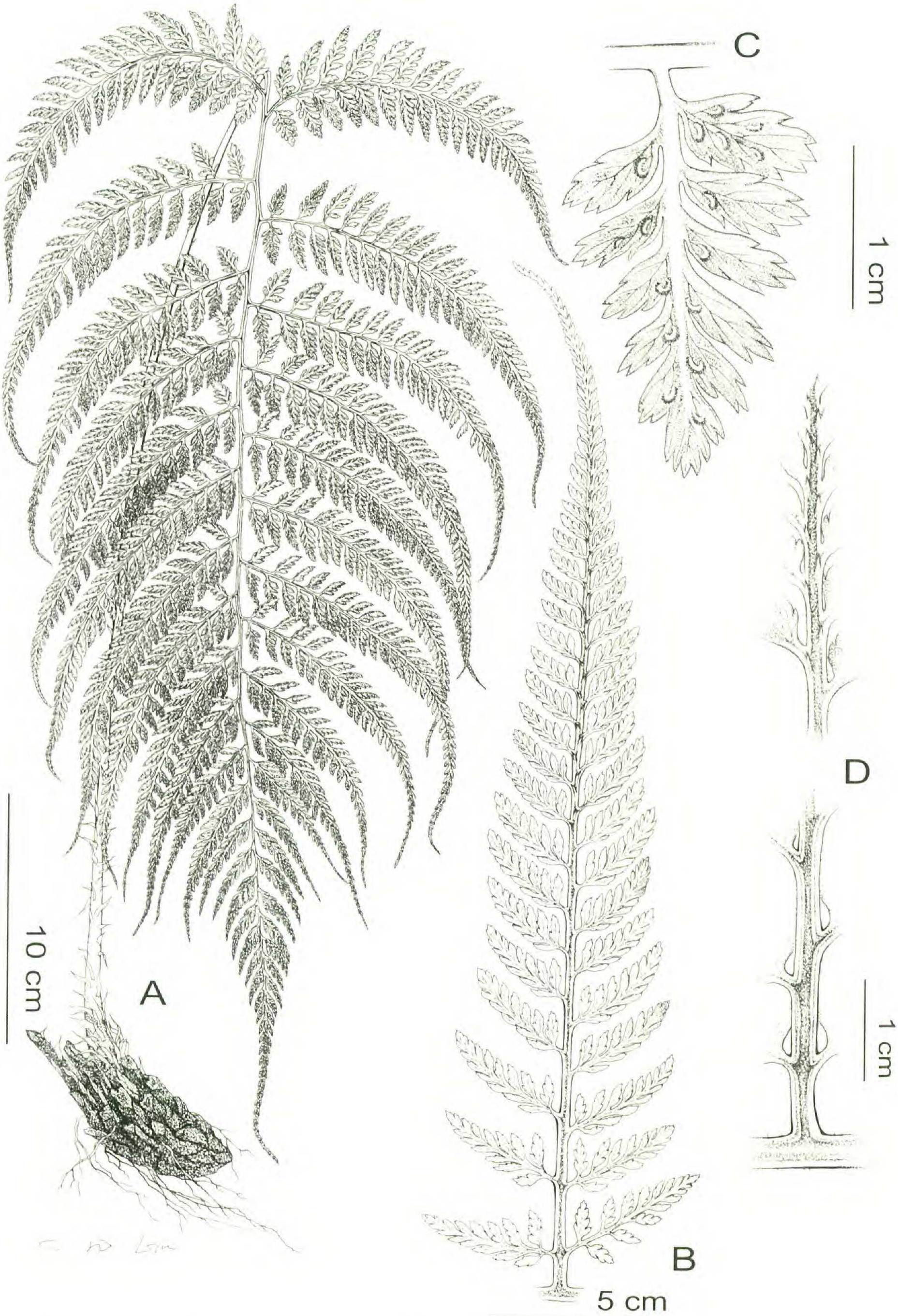

FIG. 1. Illustration of *A. tripinnatum*. **A**. Habit. **B**. Representative pinnae (adaxial surface) **C**. Representative sori position and venation (abaxial surfaces) D. Adaxial surface of costae, spines on the base of costule.

H. Lee & J. M. Cheng 2121 (TAIF); **Kaohsiung**: *Y. C. Liu 3521, 3562* (SYSU); **Hsingchu**: *P. F. Lu 1531* (TAIF).

The section *Polystichoides* is a well known natural group under the genus *Athyrium* including *A. nakanoi* Makino, *A. anisopterum* Christ, *A. micropterum* Fras.-Jenk., *A. kumaonicum* Punetha, *A. puncticaule* (Bl.) T. Moore, *A. foliolosum* and *A. fimbriatum*. The group has significant morphological characters distinct from other species of *Athyrium*: an enlarged acroscopic pinnule in the basal pinnae, or the pinnule auricled on its acroscopic side; setae or spines absent on the adaxial surface of costae and costules and spores with cristate-retate perispore (Hsieh, 1986; Wang, 1999; Liu *et al.* 2000; Chang *et al.* 2001; Liu and Fraser-Jenkins, 2006). Although *A. tripinnatum* is superficially very similar to *A. fimbriatum*, it does not match the morphological characters of the section *Polystichoides* as it has spines on the costae and a rugose perispore. This species is unique in morphology compared to other taxa in Taiwan, where it is usually found in humid and shaded forest understory and is an endemic species. According to the morphological characters distinguishing sections, we suggest *A. tripinnatum* Tagawa must belong to the section *Echinoathyrium*, though more systematic study is needed to clarify the relationship to *A. fimbriatum* and *A. foliolosum* which are morphologically similar.

Athyrium minimum Ching Acta Bot. Boreal.-Occid. Sin. 6:151. 1986.

Fig. 2, 3D–F.

Evergreen, terrestrial plant; rhizome short erect. Stipes up to 10 cm long, tufted, slender, usually shorter than the lamina, green, or sometimes turning red, glabrous, but densely scaly at the base; scales ovate or broadly lanceolate, light brown, 0.5–1 cm long, entire. Lamina ovate, 25 (5–40) cm long by 10 (2–15) cm wide, acuminate, bipinnate, glabrous, papyraceous; pinnae 7–10 on each side, narrowly lanceolate, often acuminate, 4–8 cm long, 2 (1–2.5) cm wide, slightly overlapping the adjacent ones, with short petioles (1–3 mm), costae narrowly canaliculated and with spines on the adaxial surface; pinnules anadromous slightly ascending, very shortly petiolulate, obtuse, with acute teeth at the apex, deeply lobed; rachis naked, canaliculate on the adaxial side as is the stipe, glabrous in the grooves. Sori 6–11 in a pinnule, dorsal in the middle of veinlets, J-shaped, 1–2.5 mm long; indusium membraneous, entire.

DISTRIBUTION.—Endemic to Taiwan, only occurring in the northern part, in Yangminshan National Park, from Lengshuikeng to Mt. Chihsing, Altitude ca. 800–950 m.

SPECIMENS EXAMINED.—TAIWAN. **Tamshui**: *Hancock, s.n.* Dec. 1881. Kew Fern List No. 134. (Holotype, PE!); **Taipei** alt. 600–800 m, *Y. C. Liu 3602* (SYSU); *P. F. Lu 1842, 1843, 2971* (TAIF).

During his taxonomic investigation of *Athyrium* in Taiwan, the first author, Yea-Chen Liu, found that some specimens of the genus collected from Yangmingshan National Park, north Taiwan, could not be determined as belonging to any known species. The plants varied in sizes from 5 to 40 cm in

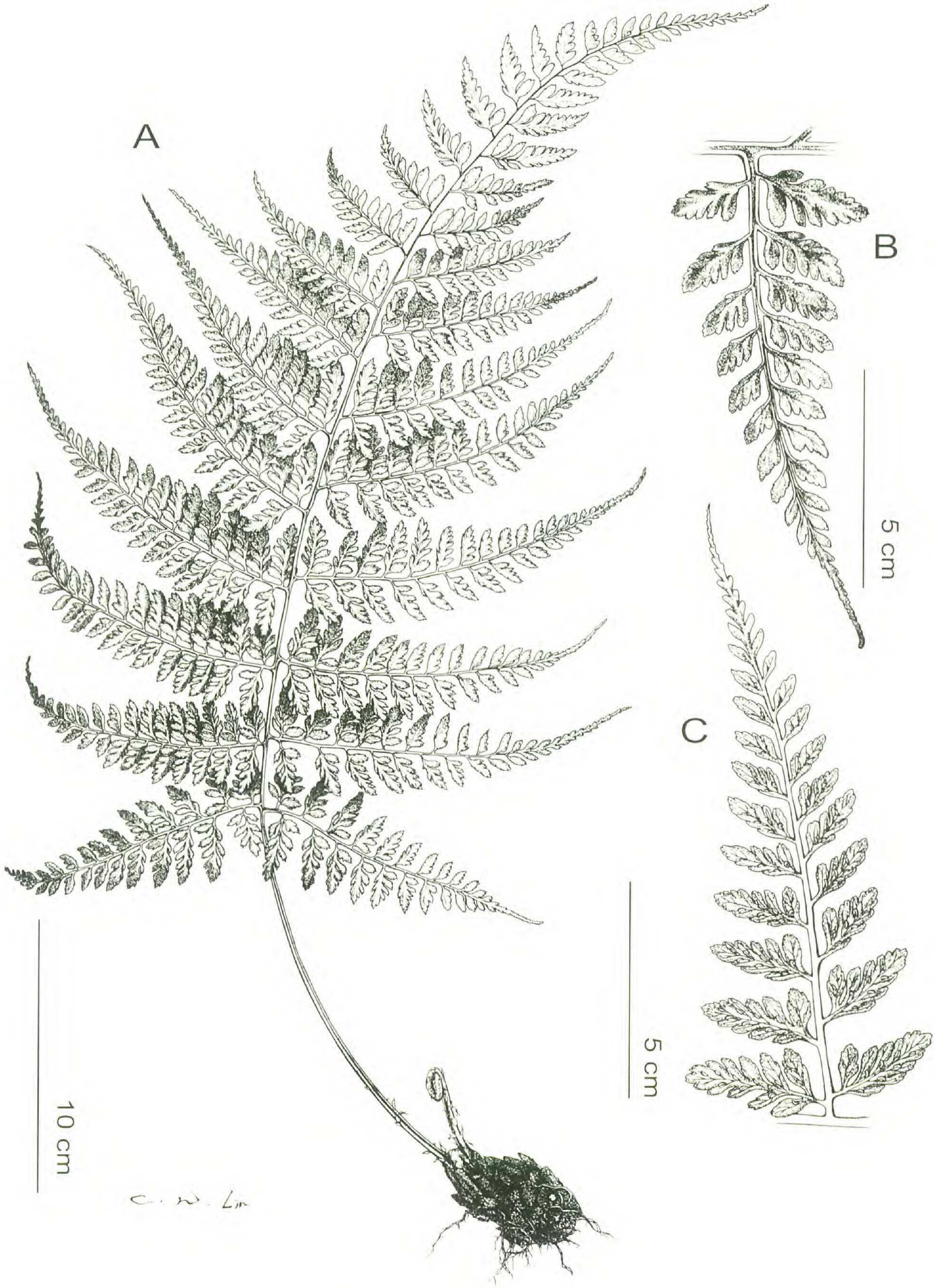

FIG. 2. Illustration of *Athyrium minimum*. **A**. Habit. **B**. Representative pinnae (adaxial surface) **C**. Representative sori position and venation (abaxial surfaces).

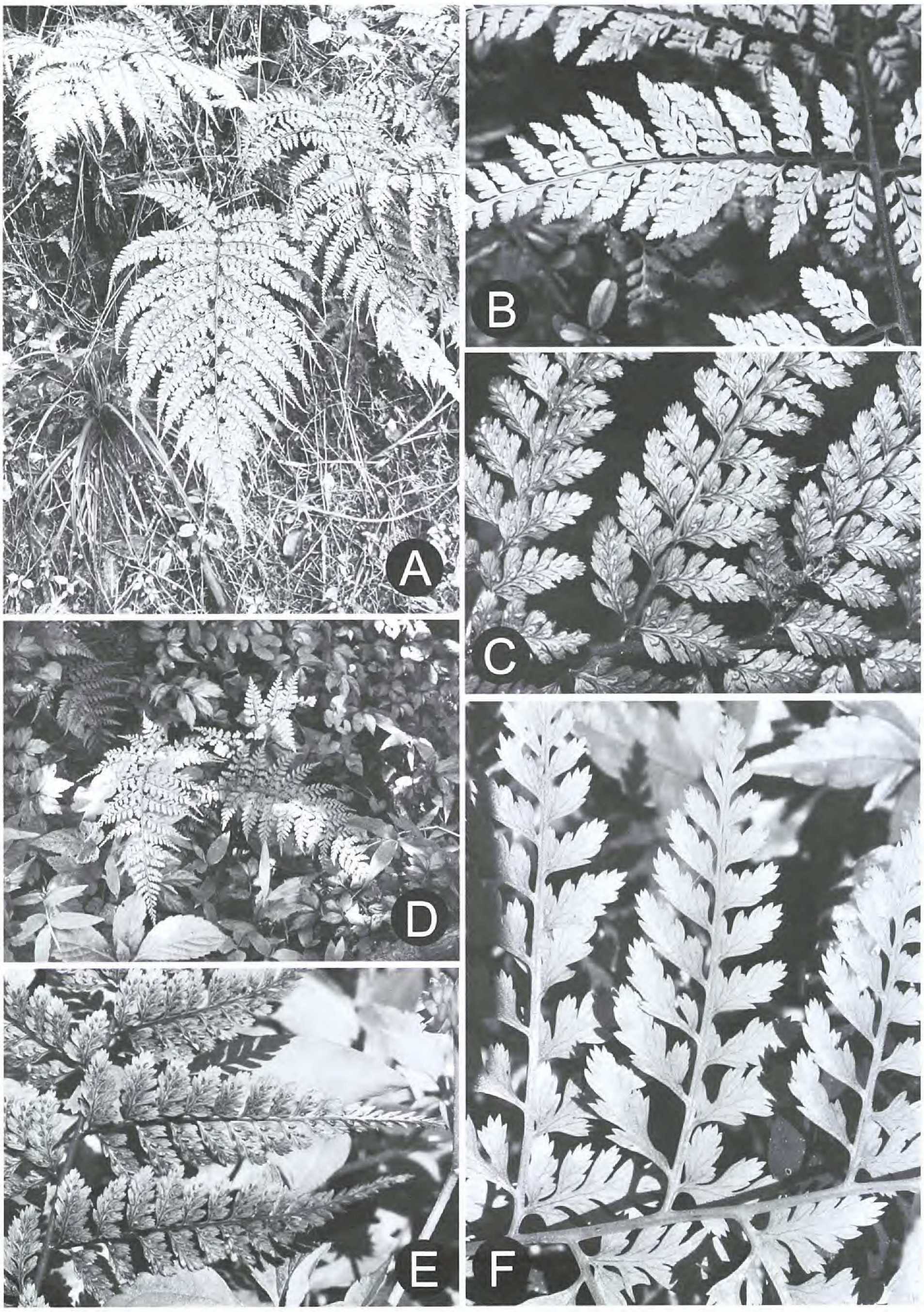

FIG. 3. *Athyrium tripinnatum* and *Athyrium minimum*. A–C *A. tripinnatum*. A. Habitat, B. Adaxial side view of lower pinnae base, C. Abaxial side view of pinnae; D–F *A. minimum*. D. Habitat, E. Adaxial side view of pinnae, F. Abaxial side view of pinnae.

frond length. When investigating native populations of it, the authors found that the quite small plants within the population were fertile and corresponded to the type specimen of *A. minimum*. Smaller individuals were usually found growing on huge moss-covered rocks and larger plants were growing on the slopes of a streamlet. Plant-size showed a cline of variation between the two types of habitat. Except for their variable size, they all resembled the type specimen of *A. minimum* in frond-morphology. Before the present report, *A. minimum* was only known from the type specimen, which has three small plants on the sheet. *Athyrium minimum* was difficult to recognize as, from the type specimen, it looked similar to small plants of different candidate species but did not appear to be, distinctly, any one of these species. Basing his identification on only one specimen led Wang (1997) to treat *A. minimum* as belonging to a distinct section *Minima* Z. R. Wang. However, based on more specimens and on observations of the native populations in the field in Taiwan, we believe it belongs to section *Echinoathyrium*, whereto we now transfer it.

Athyrium minimum looks similar to *A. iseanum*, but the latter has obvious long-soft spines on the adaxial side of costae and costules, and its chestnut-colored to dark brown lanceolate scales are different from those of the former. Furthermore, these two species have different habitats in Taiwan. *Athyrium iseanum* occurs mainly on the flat floor of shaded forests, at an altitude of 1700–2500 m, but *A. minimum* populations of ca. 100 individuals could only be found at lower altitudes, from 800–950 m in the Yangminshan area of north Taiwan.

Key to sections and species that could be confused with *A. tripinnatum* and *A. minimum* in Taiwan

1. Upper surface of frond without spine-like processes along the costae and costules. 2
   2. Rhizome short creeping; pinnae sessile, not auricled at acroscopic pinnae bases . . . . . Sect. *Niponica*
   2. Rhizome erect, pinnae petiolate, auricled at acroscopic pinnae bases . . Sect. *Polystichoides*
1. Upper surface bearing spines/setae along the costae and/or costules, perispore without folds 3
   3. Indusia usually short-linear or oblong, straight, lateral along the veinlets, often close to the segment-midrib; scales at stipe-bases often black or dark-brown. . . . . Sect. *Otophora*
   3. Indusia J-shaped, horseshoe-shaped, reniform, elliptic, short-linear etc., lateral, crossing or dorsal on veinlets; scales at stipe bases often yellow-brown, brown or dark brown . . . . . Sect. *Echinoathyrium*, 4
      4. Pinnules or lobes of supra-medial pinnae catadromic or subopposite; rachis and costae usually pale purplish red, occasionally stramineous, pubescent abaxially. . . . . *A. vidalii* (Fr. *et* Sav.) Nakai
      4. Pinnules or lobes of supra-medial pinnae anadromous, occasionally catadromic or subopposite, rachis and costae stramineous, rarely pale purplish red, glabrous or sparsely pubescent abaxially 5
         5. Fronds bipinnatifid, pinnules or lobes downwards-reflexed or not flat. . . . . *A. oppositipenna* Hayata
         5. Fronds tripinnatifid to tripinnate, pinnules or lobes flat 6
            6. Adaxial surface of costae and costules pubescent; frond length usually more than 50 cm . . . . . *A. tripinnatum*
            6. Adaxial surface of costae and costules glabrous, or sparsely pubescent on grooves; frond length usually less than 40 cm. . . . . *A. minimum*

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